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Electrical apparatus for the detection and measurement of oxygen — Performance requirements and test methods

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National foreword

This British Standard is the UK implementation of EN 50104:2010. It supersedes BS EN 50104:2002 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GEL/31/19, Gas detectors.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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English version

Electrical apparatus for the detection and measurement of oxygen - Performance requirements and test methods

Appareils électriques de détection et de mesure de l'oxygène - Règles de performance et méthodes d'essai

Elektrische Geräte für die Detektion und Messung von Sauerstoff - Anforderungen an das Betriebsverhalten und Prüfverfahren

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

This European Standard was prepared by SC 31-9, Electrical apparatus for the detection and measurement of combustible gases to be used in industrial and commercial potentially explosive atmospheres, of Technical Committee CENELEC TC 31, Electrical apparatus for potentially explosive atmospheres, on the basis of EN 50104:2002. It was submitted to the Unique Acceptance Procedure and approved by CENELEC as EN 50271 on 2010-06-01.

This document supersedes EN 50104:2002 + A1:2004.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2011-06-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2013-06-01

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and covers essential requirements of EC Directive 94/9/EC. See Annex ZZ.

The State of the Art is included in Annex ZY "*Significant changes between this European Standard and EN 50104:2002*".

Contents

1 Scope

This European Standard specifies general requirements for construction, testing and performance, and describes the test methods that apply to portable, transportable and fixed apparatus for the measurement of the oxygen concentration in gas mixtures indicating up to 25 % (v/v). The apparatus, or parts thereof, may be intended for use in potentially explosive atmospheres (see 4.1) and in mines susceptible to firedamp.

In the case of inert gas purging (inertization), it applies also to apparatus with an oxygen measuring function for explosion protection.

NOTE Commonly used oxygen sensors in commercial equipment for industrial application are:
a) paramagnetic sensors;
b) electrochemical sensors (aqueous and solid electrolytes);
c) tunable diode laser absorption spectroscopy sensors (TDLAS).

This standard is also applicable when an apparatus manufacturer makes any claims regarding any special features of construction or superior performance that exceed the minimum requirements of this standard. All such claims shall be verified and the test procedures shall be extended or supplemented, where necessary, to verify the claimed performance. The additional tests shall be agreed between the manufacturer and test laboratory and identified and described in the test report.

This European Standard is applicable to oxygen alarm apparatus intended to measure reliably the oxygen concentration, to provide an indication, alarm or other output function, the purpose of which is to give a warning of a potential hazard and, in some cases, to initiate automatic or manual protective action(s), whenever the level exceeds or falls below a preselected alarm concentration.

This standard is applicable to apparatus, including integral sampling systems of aspirated apparatus, intended to be used for commercial, industrial and non-residential safety applications.

This standard does not apply to external sampling systems, or to apparatus of laboratory or scientific type, or to medical equipment, or to apparatus used only for process control purposes. For apparatus used for sensing the presence of multiple gases, this standard applies only to the measurement of oxygen.

This standard is also applicable to apparatus using optical principles (e.g. TDLAS), where the optical transmitter and receiver or the optical transceiver (i.e. combined transmitter and receiver) and a suitable reflector are not located in a common enclosure. However, in this case it will be necessary to modify the test conditions described in Clause 5 and to introduce supplementary tests to Clause 6 of this standard. Such supplementary tests will include alignment, beam block fault, long range operation. Guidance to appropriate modification of the test conditions and supplementary tests may be taken from EN 60079-29-4. Modifications of the test conditions as well as modified and supplementary tests shall be agreed between the manufacturer and test laboratory and identified and described in the test report.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 50270	Electromagnetic compatibility - Electrical apparatus for the detection and measurement of combustible gases, toxic gases or oxygen
EN 50271	Electrical apparatus for the detection and measurement of combustible gases, toxic gases or oxygen - Requirements and tests for apparatus using software and/or digital technologies
EN 60079-0	Explosive atmospheres - Part 0: Equipment - General requirements (IEC 60079-0)
EN 60079-29-4	Explosive atmospheres - Part 29-4: Gas detectors - Performance requirements of open path detectors for flammable gases (IEC 60079-29-4)

3 Definitions

For the purposes of this document, the following terms and definitions apply.

3.1 Gas properties

3.1.1
ambient air
normal atmosphere surrounding the apparatus

3.1.2
poisons (for sensors)
substances which lead to temporary or permanent loss of sensitivity of the sensors

3.1.3
reference air
air, under normal ambient conditions, with an oxygen concentration of (21 ± 0,4) % (v/v)

3.1.4
standard test gas
test gas with a composition specified for each apparatus to be used for all tests unless otherwise stated (see 5.3.2)

3.1.5
volume fraction (v/v)
quotient of the volume of a specified component and the sum of the volumes of all components of a gas mixture before mixing, all volumes referring to the pressure and the temperature of the gas mixture

NOTE The volume fraction and volume concentration take the same value if, at the same state conditions, the sum of the component volumes before mixing and the volume of the mixture are equal. However, because the mixing of two or more gases at the same state conditions is usually accompanied by a slight contraction or, less frequently, a slight expansion, this is not generally the case.

3.1.6
zero test gas
gas, such as nitrogen, which is free of oxygen, and interfering and contaminating substances

3.2 Types of apparatus

3.2.1
alarm-only apparatus
apparatus having an alarm but not having a meter or other indicating device

3.2.2
aspirated apparatus
apparatus that samples the gas by drawing it to the gas sensor, for example, by means of a hand-operated or electric pump

3.2.3
automatically aspirated apparatus
aspirated apparatus with an integral pump

3.2.4
continuous duty apparatus
apparatus that is powered for long periods of time, but may have either continuous or intermittent sensing

3.2.5
diffusion apparatus
apparatus in which the transfer of gas from the atmosphere to the gas sensor takes place by random molecular movement, i.e. under conditions in which there is not aspirated flow

3.2.6
fixed apparatus
apparatus that is intended to have all parts permanently installed

3.2.7
portable apparatus
apparatus that has been designed to be carried readily from place to place and to be used while it is being carried. A portable apparatus is battery powered and includes, but is not limited to

a) a hand-held apparatus, typically less than 1 kg, suitable for one-handed operation without accessories (such as sampling probes, sample lines) fitted,

b) personal monitors, similar in size and mass to the hand-held apparatus, that are continuously operating (but not necessarily continuously sensing) while they are attached to the user, and

c) another apparatus that can be operated by the user while it is carried either by hand, by a shoulder strap or carrying harness, and which may or may not have a hand-directed probe

3.2.8
spot-reading apparatus
apparatus intended to be used for short, intermittent or irregular periods of time as required (typically 5 min or less)

3.2.9
transportable apparatus
apparatus not intended to be portable, but which can be readily moved from one place to another

3.2.10
stand-alone gas detection apparatus
fixed gas detection apparatus that provide a conditioned electronic signal or output indication to a generally accepted industry standard (such as 4-20 mA), intended to be utilized with stand-alone control units, or signal processing data acquisition, central monitoring and similar systems which typically process information from various locations and sources including, but not limited to, gas detection apparatus

3.2.11
stand-alone control unit
fixed gas detection control units intended to provide meter indication, alarm functions, output contacts and/or alarm signal outputs when utilized with stand-alone gas detection apparatus

3.3 Sensors

3.3.1
integral sensor
sensor which is integral to the main body of the apparatus

3.3.2
measuring principle
type of physical or physico-chemical detection principle and the measurement procedure to determine the measured value

3.3.3
remote sensor
sensor which is not integral to the main body of the apparatus

3.3.4
sensing element
part of the sensor which directly picks up the quantity to be measured and which is sensitive to that quantity

3.3.5
sensor
assembly in which the sensing element is housed and which may also contain associated circuit components

3.4 Supply of gas to apparatus

3.4.1
sample line
a means by which the gas being sampled is conveyed to the sensor including accessories, e.g. filter, water trap

3.4.2
sampling probe
separate sample line which is attached to the apparatus as required, that may or may not be supplied with the apparatus. It is usually short (e.g. in the order of 1 m) and rigid (although it may be telescopic), but it may be connected by a flexible tube to the apparatus

3.5 Signals and alarms

3.5.1
alarm set point
fixed or adjustable setting of the apparatus that is intended to pre-set the level of concentration at which the apparatus will automatically initiate an indication, alarm or other output function

3.5.2
fault signal
audible, visible or other type of output, different from the alarm signal, permitting, directly or indirectly, a warning or indication that the apparatus is not working satisfactorily

3.5.3
latching alarm
alarm that, once activated, requires deliberate action to be deactivated

3.5.4
repeatability
closeness of agreement between the results of successive measurements of the same value of the same quantity carried out by the same method, with the same measuring instruments, by the same observer, in the same laboratory at quite short intervals of time in unchanged conditions

3.6 Times

3.6.1
drift
variation in the apparatus indication with time, at any fixed gas volume fraction under constant ambient conditions

3.6.2
final indication
indication given by the apparatus after stabilisation

3.6.3
stabilisation
state when three successive readings of an apparatus, taken at 2 min intervals, indicate no changes greater than ± 1 % of the measuring range

3.6.4
time of response t_x (not applicable to spot-reading apparatus)
time interval, with the apparatus in a warmed-up condition, between the time when an instantaneous variation in volume fraction is produced at the apparatus inlet and the time when the response reaches a stated percentage (x) of the difference between the initial and the final indication

3.6.5
minimum time to operate (spot-reading apparatus)
time interval between the initiation of a measurement procedure and the time when the apparatus indication reaches a stated percentage of the final indication

3.6.6
warm-up time (not applicable to spot-reading apparatus)
time interval, with the apparatus in a stated atmosphere, between the time when the apparatus is switched on and the time when the indication reaches and remains within the stated tolerances (see Figure 1)

4 General requirements

4.1 Introduction

The apparatus shall comply with the requirements of this standard.

Electrical assemblies and components shall comply with the construction and test requirements of 4.2, where applicable. In addition, parts of the gas detection apparatus intended for use in potentially explosive atmospheres shall employ materials, and comply with the construction and explosion protection as specified in the appropriate regulations for explosion protection.

4.2 Construction

4.2.1 General

Gas detection apparatus or parts thereof (e.g. remote sensors) specifically intended for use in the presence of corrosive vapours or gases shall be constructed of materials known to be resistant to corrosion by such substances.

All apparatus shall be constructed to facilitate regular accuracy checks.

All materials and components used in the construction of the apparatus shall be used within the manufacture’s ratings or limitations unless otherwise specified by appropriate safety standards.

4.2.2 Indicating devices

An indication shall be provided to show that the apparatus is energised.

NOTE The indication may be shown at the control unit.

For alarm-only apparatus or apparatus where the resolution of the read-out device is inadequate to demonstrate compliance with this standard, the manufacturer shall identify suitable points for connecting additional indicating or recording devices for the purpose of testing the compliance of the apparatus with this standard. The indication on the read-out device of the apparatus shall not contradict the results obtained by the additional indicating or recording devices.

Any under-range or over-range measurements shall be clearly indicated.

If the apparatus has more than one measuring range, the range selected shall be clearly identified.

If only one indicating light is provided for signalling alarms, faults and other indications, it shall be coloured red. If separate indicating lights are used or if a multi-coloured indicating light is provided, the colours shall be used in the following order of priority ((a) being highest priority):

a) alarms indicating the presence of gas at potentially dangerous levels shall be coloured RED;

b) equipment fault indicators shall be coloured YELLOW;

c) power supply indicators shall be coloured GREEN.

In addition to the colour requirements, the indicator lights shall be adequately labelled to show their functions.

4.2.3 Alarm or output functions

Alarm devices shall not be adjustable to operate outside the measuring range.

If alarm devices, output contacts or alarm signal outputs are provided as part of fixed or continuous duty portable apparatus and are intended to operate when a potentially hazardous gas concentration is detected, they shall be of a latching type requiring a deliberate manual action to reset. If two or more alarm set points having the same direction (activation at increasing or decreasing oxygen concentration, respectively) are provided, the first alarm may be non-latching - based on user preference.

NOTE 1 The latching device may reside in software.

Alarms shall remain in operation while the alarm condition is still present. An additional audible alarm may be silenced.

NOTE 2 This implies that it may not be possible to switch off the apparatus if an alarm condition is present.

If it is possible to de-activate alarm devices, output contacts or alarm signal outputs, e.g. for calibration purposes, this deactivation shall be indicated by a signal. For fixed apparatus, this shall include a contact or other transmittable output signal. Alternatively, the output signal or contacts are not required if the alarms are automatically re-enabled within 15 min.

4.2.4 Fault signal

Fixed and transportable apparatus shall provide a fault signal in the event of failure of power to the apparatus. A short circuit or open circuit in connections to any remote sensor shall be indicated by a fault signal.

Automatically aspirated apparatus shall be provided

a) in the case of fixed and transportable apparatus: with an integral flow-indicating device that produces a fault signal in the event of flow failure,

b) in the case of portable apparatus: with a means of verifying the air flow.

4.2.5 Adjustments

All adjustment devices shall be designed so as to discourage unauthorised or inadvertent interference with the apparatus. Examples would include procedural devices, in the case of a keyboard instrument, or mechanical devices such as a cover requiring the use of a tool.

Fixed explosion-protected apparatus housed in explosion-protected enclosures shall be designed so that, if any facilities for adjustments are necessary for routine recalibration and for resetting or like functions, these facilities shall be externally accessible. The means for making adjustments shall not degrade the explosion protection of the apparatus.

The adjustments of the zero and signal amplification shall be so designed that adjustments of one will not affect the other.

4.2.6 Battery-powered apparatus

Apparatus powered with integral batteries shall be provided with an indication of low battery condition, and the nature and purpose of this indication shall be explained in the manual.

4.2.7 Stand-alone gas detection apparatus for use with separate control units

A specification shall be supplied with the apparatus that describes the relationship the gas concentration (detected by the apparatus) has with the corresponding output signal or indication (transfer function). Such specification shall be detailed to the extent that the accuracy of this transfer function can be verified. As a minimum, the manufacturer shall provide data showing the relationship between the output signal and the gas concentrations corresponding to 0,10 %, 25 %, 50 %, 75 % and 100 % of full-scale output indication. Full-scale output and status signals (e.g. fault, inhibit) shall also be specified by the manufacturer.

Where necessary, equipment shall be provided by the manufacturer to interpret the output signal or indication, which will enable the accuracy of the transfer function to be verified.

4.2.8 Separate control units for use with stand-alone gas detection apparatus

A specification shall be supplied with the apparatus that describes the relationship the input signal has with the calculated gas concentration (transfer function). Such specification shall be detailed to the extent that the accuracy of this transfer function can be verified. As a minimum, the manufacturer shall provide data showing the relationship between the input signal and the gas concentrations corresponding to 0,10 %, 25 %, 50 %, 75 % and 100 % of full-scale indication. Required inputs for full-scale indication and status signals (e.g. fault, inhibit) shall also be specified by the manufacturer.

Where necessary, equipment shall be provided by the manufacturer to provide the input signals, which will enable the accuracy of the transfer function to be verified.

4.2.9 Apparatus using software and/or digital technologies

The apparatus shall fulfil the requirements of EN 50271.

4.3 Labelling and marking

The apparatus shall be marked legibly and indelibly. The following minimum requirements apply:

a) name and address of the manufacturer;

b) certification marking;

c) designation of series or type;

d) serial number, if any;

e) year of construction (may be encoded within the serial number);

f) “EN 50104” (to represent conformance with this performance standard). If due to size constraints this information cannot be put onto the apparatus, it shall be included in the instruction manual;

g) If applicable, the apparatus shall comply with the additional marking requirements of EN 60079-0.

4.4 Instruction manual

Each apparatus shall be provided with an instruction manual that includes the following information:

a) complete instructions, drawings and diagrams for safe and proper operation, installation and servicing of the apparatus;

b) adjustment procedures;

c) recommendations for initial checking and calibration of the apparatus on a routine basis, including procedures and time intervals

NOTE Users are referred to EN 60079-29-2.

d) instructions for the use of the field verification kit including sample flow rate limits, if provided;

e) details of operational limitations including, where applicable, the following:
   1) intended use (oxygen deficiency, oxygen enrichment, inertization);
   2) whether the apparatus is intended to be used in potentially explosive atmospheres;
   3) measuring principles and description of the apparatus functions;
   4) time of response t_{90};
   5) temperature limits;
   6) humidity limits;
   7) pressure limits;
   8) supply voltage limits;
   9) maximum power consumption;
   10) relevant characteristics and construction details of required interconnecting cables;
   11) for battery operated apparatus, battery type(s) and operating time(s) until low battery condition;
   12) nominal orientation and orientation limits;
   13) safety-related significance of the measuring sequence in non-continuous operation and possibilities of adapting the measuring sequence to the monitoring tasks;
   14) warm-up time;
   15) stabilisation time;
   16) gas mixtures expressly prohibited by the manufacturer;
f) details of storage life and limitations for the apparatus, replacement parts and accessories, including, where applicable, the following limits:
   1) temperature;
   2) humidity;
   3) pressure;
   4) time;
g) information on the adverse effects of poisons and interfering gases or substances on the proper performance (and, in the case of oxygen-enriched atmospheres, on electrical safety) of the apparatus;
h) for aspirated apparatus, indication of the minimum and maximum flow rates and pressure, or, for automatically aspirated apparatus, indication of the nominal flow rate and the flow rate where the flow failure signal is set or, if adjustable, the range of flow rates where the flow failure signal can be set;
i) for aspirated apparatus, tubing type, maximum length and size for proper operation;
j) for aspirated apparatus, instructions for ensuring that the sample lines are intact and that proper flow is established (see 4.2.4);
k) statements of the nature and significance of all alarms and fault signals, the duration of such alarms and signals (if time-limited or non-latching), and any provisions that may be made for silencing or resetting such alarms and signals, as applicable;
l) details of any method for the determination of the possible sources of a malfunction and any corrective procedures (i.e. trouble-shooting procedures);
m) a statement that alarm devices, outputs or contacts are of the non-latching types, where applicable (see 4.2.3);
n) for battery-operated apparatus, installation and maintenance instructions for the batteries;
o) if applicable, instructions for replacement of the sensor;
p) a recommended replacement parts list;
q) where optional accessories (e.g. collecting cones, weather-protecting devices) are supplied, the manufacturer shall list such accessories and state their effects on the apparatus characteristics (including time of response and sensitivity), and provide means for their identification (e.g. part numbers included in manual);
r) details of certification and marking, and any special conditions of service;
s) where the special nature of the apparatus (such as non-linear responses) requires additional instructions or special information that are alternative to, or in addition to, the requirements of 4.3 and 4.4 a) to r), the instructions or information shall be provided.

5 Test methods

5.1 Introduction

The test methods and procedures described in 5.2 to 5.4 are intended as a basis for establishing whether the apparatus conforms with the performance requirements given in this draft European Standard.

This standard is also applicable when an apparatus manufacturer makes any claims regarding any special features of construction or superior performance that exceed the minimum requirements of this standard. This may be increased accuracy or performance within the limits of the standard, or performance beyond the specifications of the standard. All such claims, including environmental claims, shall be verified and the test procedures shall be extended or supplemented, where necessary, to verify the claimed performance. The additional tests shall be agreed between the manufacturer and test laboratory and identified and described in the test report.

When claiming a superior performance outside these specifications, the measurement accuracy is not required to meet the standard's minimum requirements when outside this specification (e.g. for the normal temperature range of -10 °C to +40 °C the accuracy shall be ± 5 % of the measuring range, but an extended temperature range of -25 °C to -10 °C may have a wider tolerance, such as ± 10 % of the measuring range).

5.2 General requirements for tests

5.2.1 Samples and sequence of tests

5.2.1.1 General

For the purpose of type testing, the tests shall be carried out on one apparatus. Another apparatus may be used for the tests according to 5.4.4 and 5.4.23.

5.2.1.2 Sequence

The apparatus shall be subjected to all of the tests applicable to that type of apparatus, as described in 5.4. Test 5.4.2 shall be conducted prior to all other tests. The manufacturer may request a particular order of the other tests. The sequence of tests used during type testing shall be recorded. A recommended sequence is given in Annex A.

5.2.1.3 Stand alone gas detection apparatus

Stand alone gas detection apparatus shall be tested to the requirements of 5.4.2 through 5.4.16, 5.4.19 through 5.4.25 (if applicable) using the parameters of the transfer function.

5.2.1.4 Stand alone control units

Stand alone control units shall be tested to the requirements of 5.4.2, 5.4.3, 5.4.4, 5.4.6, 5.4.7, 5.4.13, 5.4.15, 5.4.16, 5.4.19, 5.4.20 and 5.4.25 using the parameters of the transfer function pertinent to the specific type of gas detector.

5.2.1.5 Test of compliance with General Requirements

Tests shall also be carried out, where applicable, to ensure that the apparatus satisfies the construction requirements of 4.2. The requirements for these tests are generally self-evident, except that for short-circuit requirements in 4.2.4, ballast resistors shall be substituted for each wire connecting the control unit to any remote sensor. The values of these resistors shall be those declared, in the instruction manual, to be the maximum lead resistances allowing satisfactory compliance with this European Standard. The device used for the short circuit shall be of negligible resistance and shall be applied to convenient points in the circuit, at the sensor ends of the ballast resistors.

5.2.1.6 Apparatus with selectable range

For apparatus having more than one selectable range or scale, each range shall be tested. For the second and subsequent ranges, the necessary amount of testing shall be agreed upon between the manufacturer and the test laboratory.

5.2.2 Preparation of apparatus before testing

The apparatus shall be prepared and mounted as near to typical service as possible, in accordance with the instruction manual, including all necessary interconnections, initial adjustments and initial calibrations. Adjustments may be made, where appropriate, at the beginning of each test.

In particular, the following points shall be noted:

a) Apparatus having remote sensors

   For the purpose of the tests in 5.4, where reference is made to exposure of the sensor to the test conditions, the entire remote sensor (including any or all normally attached protective mechanical parts) shall be exposed.

   For apparatus having connection facilities for more than one remote sensor, only one remote sensor needs to be subjected to the tests. The replacement of all but one sensor by „dummy“ impedances yielding the worst case load conditions for the test in question shall be permitted. The worst case load conditions shall be determined by the testing laboratory within the limits specified in the instruction manual.

   For apparatus having remote sensor(s), all tests shall be performed with resistances connected in the detector circuit to simulate the maximum line resistance specified by the apparatus manufacturer, except where minimum line resistance offers a more stringent test in the judgement of the test laboratory.

b) Apparatus having integral sensors

   The entire apparatus shall be exposed to the test conditions without removal of any normally attached parts, including any sampling probe for tests 5.4.11, 5.4.15, 5.4.16 and 5.4.17.

c) For alarm-only apparatus, readings shall be taken using an external indicating or recording device connected to test points described in 4.2.2.

In all cases, optional parts shall be either attached or removed according to which condition will give the most unfavourable result (at the discretion of the testing laboratory) for the test being conducted.

5.2.3 Mask for calibration and test

When a mask is used for calibration or for the injection of test gas into the sensor, the design and operation of the mask used by the testing laboratory, in particular the pressure and velocity inside the mask, shall not inadmissibly influence the response of the apparatus or the results obtained.

NOTE It is recommended that the testing laboratory should consult with the manufacturer in determining the design of the calibration mask. The manufacturer may provide with the apparatus a suitable calibration mask together with details of suggested pressure and flow rate for application of calibration gases to the apparatus.

5.3 Normal conditions for test

5.3.1 General

The test conditions specified in 5.3.2 to 5.3.11 shall be used for all tests, unless otherwise stated.

5.3.2 Test gas(es)

The volume fraction of oxygen in the standard test gas shall fall in the middle of the measuring range as defined by the manufacturer, whereas the upper limit of the measuring range shall be not greater than 25 % (v/v).

The tolerance on the nominal volume fraction of the standard test gas shall be within ± 0,5 % (v/v) of oxygen or ± 10 % of the concentration of the standard test gas, whichever is less.

When the apparatus is intended for measuring oxygen deficiency or enrichment, all tests shall be made with reference air and standard test gas.

When the apparatus is intended for measuring inertization, all tests shall be made with zero test gas and standard test gas. For apparatus with a lower limit of the measuring range above zero, a test gas with the oxygen concentration at the lower limit of the measuring range shall be used instead of zero test gas.

When the apparatus is intended for more than one application, it shall be tested for each application.

The volume fractions of the test gases shall be known to a relative expanded uncertainty of ± 2 %.

NOTE The gas mixture may be prepared by any suitable method.

5.3.3 Flow rate for test gases

When the apparatus is exposed to the test gases, the flow rate of the gas shall be in accordance with the manufacturer's instructions.

NOTE For an apparatus that samples by diffusion, either a calibration mask in accordance with 5.2.3 or a test chamber may be used.

5.3.4 Power supply

a) Fixed AC or DC powered apparatus shall be operated within 2 % of the manufacturer's recommended supply voltage and frequency.

b) Battery-powered apparatus shall, for short-term tests, be equipped with new or fully charged batteries at the commencement of each series of tests. For long-term testing, it is permissible to energise the unit from a stabilised power supply.

5.3.5 Temperature

The ambient air and test gas shall be held at a constant temperature ± 2 K within the range of 15 °C to 25 °C, throughout the duration of each test.

5.3.6 Pressure

The tests shall be performed at pressures between 86 kPa and 108 kPa, with a maximum variation of ± 1 kPa throughout the duration of each short-term test. For long-term tests, the influence of pressure changes shall be taken into account, using the results of the pressure test (5.4.8).

5.3.7 Humidity

The relative humidity (r.h.) of the ambient air and the standard test gas shall be controlled to within ± 10 % r.h. over the range 20 % to 80 % r.h. throughout each test.

For short applications of test gases, the use of dry gases is permitted if agreed between the manufacturer and the test laboratory. The properties of the sensor shall be taken into account, e.g. drying out.

5.3.8 Stabilisation time

In each instance where the apparatus is subjected to a different test condition, the apparatus shall be allowed to stabilise under these new conditions before measurements are taken.

5.3.9 Orientation

The apparatus shall be tested in the orientation recommended by the manufacturer.

5.3.10 Communications options

For apparatus having wired or wireless communications options used during normal gas detection operation, tests in 5.4.3, 5.4.7 and 5.4.16 shall be performed with all communication ports connected. The maximum transaction rate, cabling characteristics and activity level specified by the manufacturer shall be employed.

5.3.11 Gas detection systems

For gas detection systems, tests in 5.4.3, 5.4.7, 5.4.16 and 5.4.19 shall be performed with the maximum system communications transaction rate and activity level. This shall correspond to the largest and most complex system configuration permitted by the manufacturer.

5.4 Test methods and performance requirements

5.4.1 General

The following tests shall be performed in accordance with 5.3, unless otherwise stated. All tests shall be performed.

At the end of each test, indications shall be taken in both reference air or zero test gas and in the standard test gas, unless otherwise stated. The values of the indications used for verification of compliance with the performance requirements shall be the final indications (see 3.6.2) of both the reference air or zero test gas and the standard test gas readings, unless otherwise stated.

5.4.2 Unpowered storage

All parts of the apparatus shall be exposed sequentially to the following conditions in reference air only:

a) a temperature of - 20 °C ± 3 °C for 24 h;

b) ambient temperature for at least 24 h;

c) a temperature of 40 °C ± 2 °C for 24 h;

d) ambient temperature for at least 24 h.

At each temperature, the humidity of the clean air shall be so that condensation does not occur.

The above temperatures may be varied only after an agreement has been reached between the manufacturer and testing laboratory. Where temperatures other than those listed above are used, they shall be listed in the test report.

Performance requirements: After being submitted to the conditions specified above, the apparatus shall meet the requirements specified in 5.4.3 to 5.4.26.

5.4.3 Calibration, adjustment and repeatability

5.4.3.1 Initial preparation of the apparatus

The apparatus shall be calibrated and adjustments shall be carried out, if needed, to obtain correct indications in accordance with the manufacturer’s instruction manual.

5.4.3.2 Calibration curve

The apparatus shall be exposed to four test gases, two of which shall have an oxygen volume fraction at the lower limit of the measuring range (e.g. zero test gas for apparatus intended for measuring inertization) and a volume fraction near to the upper limit of the measuring range respectively. The test gas volume fractions shall be evenly distributed over the measuring range. The gas with the lowest volume fraction shall be applied first in the sequence, followed by the other test gases in order of increasing volume fraction. The application of the first three gases shall be repeated in the reverse order, i.e. in order of decreasing volume fraction, ending with the lowest volume fraction.

This operation shall be carried out three times consecutively, giving four measured values for the gas with the lowest oxygen volume fraction, three at the highest volume fraction, and six at each of the intermediate volume fractions.

Performance requirements: Each individual indication in the three sets of indications obtained for each of the four gas volume fractions shall not differ from these volume fractions by more than ± 0,2 % (v/v) of oxygen or ± 2,5 % of the measuring range, whichever is the greater.

5.4.3.3 Repeatability

Expose the apparatus to either zero test gas or reference air, and then to standard test gas and record the measurement in each case. The duration of the application of the test gases shall be three times the time of response t_{90} of the apparatus for concentration rise or concentration drop. Repeat this cycle nine more times.

Performance requirement: The standard deviation of the values shown at the end of the gas application shall be smaller than ± 0,1 % (v/v) of oxygen or ± 1 % of the measuring range, whichever is the greater.

5.4.4 Stability (continuous duty apparatus only)

NOTE For these tests, battery-powered apparatus should be powered from internal batteries wherever possible, otherwise an external power supply may be used.

5.4.4.1 Fixed and transportable apparatus

The apparatus shall be operated continuously in reference air (apparatus intended for measuring oxygen deficiency or enrichment) or in zero test gas (apparatus intended for measuring inertization) for a period of two months. At the end of every week, the apparatus shall be exposed to standard test gas, until stabilised. Indications shall be taken prior to both the application and removal of the standard test gas.

Performance requirement: The variation of the indications under either zero test gas or reference air and under standard test gas as determined by linear regression shall not exceed ± 5 % of the measuring range or ± 0,4 % (v/v) oxygen per two months, whichever is the greater.

5.4.4.2 Portable apparatus

The apparatus shall be operated continuously in reference air (apparatus intended for measuring oxygen deficiency or enrichment) or in zero test gas (apparatus intended for measuring inertization) for a period of 8 h per working day over a total of 20 working days. In the remaining time, the apparatus shall be switched off and exposed to ambient air. At the end of every 5 working days, the apparatus shall be exposed to zero test gas or reference air, and standard test gas, until stabilised. Indications shall be taken prior to both the application and removal of each gas.

Performance requirement: The variation of the indications under either zero test gas or reference air and under standard test gas as determined by linear regression shall not exceed ± 2,5 % of the measuring range or ± 0,2 % (v/v) oxygen per 20 working days, whichever is the greater.

5.4.5 Stability (spot-reading apparatus only)

The apparatus shall be exposed to standard test gas for 1 min followed by either zero test gas or reference air for 1 min. The operation shall be repeated 200 times. Indications shall be taken prior to both the application and removal of each gas.

NOTE For this test, battery-powered apparatus should be powered from internal batteries wherever possible, otherwise an external power supply may be used.

Performance requirement: The variation of the indications under either zero test gas or reference air and under standard test gas shall not be more than ± 2,5 % of the measuring range or ± 0,2 % (v/v) of oxygen, whichever is the greater.

5.4.6 Alarm set point(s)

5.4.6.1 General

When the apparatus is provided with either

a) externally adjustable means of setting either one or more alarm set points, or

b) internally pre-set alarm point(s),

the activation of such alarms by gas at the appropriate set point values shall be verified by using test gases as described in 5.4.6.2 up to 5.4.6.5. In all cases, the test gas shall be applied until either activation of the alarm(s) or twice the respective t_{90}, whichever is less.

For apparatus with several alarm set points, these tests shall be carried out for each alarm set point.

If a latching alarm is provided, the latching and the manual reset action shall be checked.

The selected alarm set points shall not change when the measuring range is changed.

5.4.6.2 Increasing oxygen concentration (apparatus intended for measuring oxygen deficiency or enrichment)

For apparatus of type a), set the alarm set point at 10 % relative below the volume fraction of the reference air. If the alarm set point cannot be set at this concentration the alarm shall be set as near as possible to that concentration. In this case and for apparatus of type b), the test gas shall have a volume fraction of 10 % relative above the concentration of the alarm set point.

Expose the apparatus to standard test gas, and then to reference air or the specified test gas above.

Performance requirement: The alarm shall activate following application of the reference air or the specified test gas.

5.4.6.3 Increasing oxygen concentration (apparatus intended for measuring inertization)

For apparatus of type a), set the alarm set point at 10 % relative below the volume fraction of the standard test gas. If the alarm set point cannot be set at this concentration, the alarm shall be set as near as possible to that concentration. In this case and for apparatus of type b), the test gas shall have a volume fraction of 10 % relative above the concentration of the alarm set point.

Expose the apparatus to zero test gas, and then to standard test gas or the specified test gas above.

Performance requirement: The alarm shall activate following application of the standard test gas or the specified test gas.

5.4.6.4 Decreasing oxygen concentration (apparatus intended for measuring oxygen deficiency or enrichment)

For apparatus of type a), set the alarm set point at 10 % relative above the volume fraction of the standard test gas. If the alarm set point cannot be set at this concentration, the alarm shall be set as near as possible to that concentration. In this case and for apparatus of type b), the test gas shall have a volume fraction of 10 % relative below the concentration of the alarm set point.

Expose the apparatus to reference air, and then to standard test gas or the specified test gas above.

Performance requirement: The alarm shall activate following application of the standard test gas or the specified test gas.

5.4.6.5 Decreasing oxygen concentration (apparatus intended for measuring inertization)

For apparatus of type a), set the alarm set point at 10 % of the measuring range. If the alarm set point cannot be set at this concentration, the alarm shall be set as near as possible to that concentration. In this case and for apparatus of type b), the test gas shall have a volume fraction of 10 % relative below the concentration of the alarm set point.

Expose the apparatus to standard test gas, and then to zero test gas or the specified test gas above.

Performance requirement: The alarm shall activate following application of the zero test gas or the specified test gas.

5.4.7 Temperature

This test shall be performed in a temperature chamber having the capability of holding the sensor or apparatus at the specified temperature within ± 2 °C. When the apparatus (or the portion under test) has reached the specified temperature, the sensor shall be exposed sequentially to zero test gas or reference air, and then standard test gas, which shall be at the same temperature as the atmosphere in the test chamber. The dew point of the test gases shall be below the lowest temperature of the test chamber and kept constant during the test.

Tests shall be carried out:

- For control units:
  at temperatures of 5 °C, 20 °C and 55 °C;

- For remote sensors and all types of apparatus with integral sensors:
  at temperatures of - 10 °C, 20 °C and 40 °C.

Performance requirement: For control units, the variation of the indications from that at 20 °C in zero test gas or reference air, and standard test gas shall not exceed ± 3 % of the measuring range. For all other types of apparatus, the variation of the indications from that at 20 °C in zero test gas or reference air, and standard test gas shall not exceed ± 5 % of the measuring range or ± 0,5 % (v/v) of oxygen, whichever is the greater.

5.4.8 Pressure

The effects of pressure variation shall be observed by placing the sensor or apparatus (including the aspirator for aspirated apparatus) in a test chamber that permits the pressure of the test gases to be varied. The pressure shall be maintained at the specified levels for 5 min, before a reading is accepted or a test is made.

Tests shall be carried out at pressures of 80 kPa, 100 kPa and 120 kPa.

NOTE The pressure should be changed with a rate less than 10 kPa/h.

Readings shall be taken with either zero test gas or reference air, and then standard test gas.

Performance requirement: The variation of the indications in either zero test gas or reference air, and standard test gas from that at 100 kPa shall not exceed ± 22 % of the measured value at 100 kPa or ± 0,2 % (v/v) of oxygen, whichever is the greater.

5.4.9 Humidity

Zero test gas or reference air with the specified humidities shall be supplied separately to the sensor using a temperature chamber or test mask. The procedure shall then be repeated with standard test gases with the specified humidities. The relative humidity levels shall be known to within ± 3 % r.h.

The volume fraction of the gas of interest shall be held constant, or due allowance shall be made of changes in oxygen volume fraction due to the pressure of water vapour in the test gas.

Tests shall be carried out at humidities of 20 % r.h., 50 % r.h. and 90 % r.h. at a temperature of 40 °C.

Performance requirement: The variation of the indications from that at 50 % r.h. shall be not more than ± 2,5 % of the measuring range or ± 0,2 % (v/v) of oxygen, whichever is the greater.

5.4.10 Air velocity

The effects of air speed over a range of 0 m/s to 6 m/s on apparatus with sensors that operate by diffusion shall be determined by the following test with reference air (apparatus intended for measuring oxygen deficiency or enrichment) or in standard test gas (apparatus intended for measuring inertization).

The separate sensors of apparatus with remote sensors and, if applicable, the entire apparatus if the sensors are integral, shall be tested in a flow chamber under no forced ventilation conditions and at speeds of 3 m/s and 6 m/s.

NOTE 1 The flow chamber should be suitable for the application of reference air or standard test gas.

The apparatus shall be tested in the orientation recommended by the manufacturer. The orientation of the sensor shall be kept constant during the test. The direction of the flow shall be such that the flow reaches the sensor from each of the three mutually perpendicular directions.

NOTE 2 Directions of flow which are not likely to occur in practice, due to the design of the apparatus, or which are expressly prohibited by the manufacturer may not be tested.

NOTE 3 If there is one direction of flow for which the effect of air speed depends on whether the flow is incident or emergent with respect to the sensor inlet (e.g. sintered metal plate), both cases shall be tested.

Performance requirement: The variation of the indication shall not exceed ± 2,5 % of the measuring range or ± 0,2 % (v/v) of oxygen, whichever is the greater.

5.4.11 Flow rate

For automatically aspirated apparatus, an adjustable flow failure signal shall be set to the minimum set point. The apparatus shall then be tested by varying the flow rate

- from 130 % of the nominal flow rate or, if this is not possible, from the nominal flow rate,
- to the flow rate at which the flow failure signal is set.

All other aspirated apparatus shall be tested by varying the flow rate from the maximum to the minimum value as specified in the instruction manual.

Performance requirement: The variation of the indication in zero test gas or reference air, and standard test gas in these tests shall not exceed ± 0,2 % (v/v) of oxygen or ± 2,5 % of the measuring range, whichever is the greater. For automatically aspirated apparatus, the flow failure signal shall be activated.

5.4.12 Orientation

5.4.12.1 Portable apparatus and mobile sensors of fixed apparatus

The sensor, or the whole apparatus if relevant, shall be rotated through 360° in steps of 90° around each of its three mutually perpendicular axes, and measurements shall be recorded in each position in zero test gas or reference air, and in standard test gas.

Performance requirement: The variation of the indication in zero test gas or reference air, and standard test gas shall not exceed ± 0,2 % (v/v) of oxygen or ± 2,5 % of the measuring range, whichever is the greater.

5.4.12.2 Fixed and transportable apparatus

The sensor, or the apparatus having an integral sensor, shall be tested within the orientation limits stated in the manufacturer's instructions in steps of 15° around each of the three mutually perpendicular axes, but with an inclination of ± 15° from the nominal orientation, if the manufacturer has stated orientation limits of ± 15° or less.

Performance requirement: The variation of the indication in zero test gas or reference air, and standard test gas shall not exceed ± 0,2 % (v/v) of oxygen or ± 2,5 % of the measuring range, whichever the greater.

5.4.13 Vibration

5.4.13.1 Test equipment

The vibration test machine shall consist of a vibrating table capable of producing a vibration of variable frequency and variable constant displacement (peak-to-peak), with the test apparatus mounted in place, as required by the following test procedures.

5.4.13.2 Procedures

5.4.13.2.1 General

The apparatus shall be energized and mounted on the vibration test machine and vibrated successively in each of three planes respectively parallel to each of the three major axes of the apparatus.

The apparatus shall be mounted on the vibration table in the same manner as intended for service use including any resilient mounts, carrier or holding devices that are provided as standard parts of the apparatus.

The alarm set point shall be set

- for apparatus intended for measuring oxygen deficiency at 10 % relative below the concentration of the reference air,
- for apparatus intended for measuring oxygen enrichment at 10 % relative above the concentration of the reference air, and
- for apparatus intended for measuring inertization at 10 % of the measuring range.

If the alarm set point cannot be set at this concentration, the alarm shall be set as near as possible to that concentration.

Before, and after conclusion of the test, measurements shall be taken in either zero test gas or reference air, and in standard test gas.

During vibration, the apparatus shall be operated in ambient air and either reference air or zero test gas shall be applied to the sensor.

The apparatus shall be vibrated over the frequency range specified at the excursion or constant acceleration peak specified, for a period of 1 h in each of the three mutually perpendicular planes. The rate of change of frequency shall be 10 Hz/min.

5.4.13.2.2 Procedure 1

For portable and transportable apparatus, remote sensors, and control units where the sensor is integral with or directly attached to the control unit, the vibration shall be as follows:

- 10 Hz to 30 Hz, 1,0 mm total excursion;
- 31 Hz to 150 Hz, 19,6 m/s² acceleration peak.

Performance requirement: During the vibration test, the apparatus shall not suffer any loss of function and shall not give a false alarm or fault signal. The apparatus shall not suffer damage resulting in a hazard or loss of function.

The variation of the indication in zero test gas or reference air, and standard test gas from that determined prior to the test shall not exceed ± 0,2 % (v/v) of oxygen or ± 2,5 % of the measuring range, whichever is the greater.

5.4.13.2.3 Procedure 2

For control units intended to be installed remotely from the sensor, the vibration shall be as follows:

- 10 Hz to 30 Hz, 1,0 mm total excursion;
- 31 Hz to 100 Hz, 19,6 m/s² acceleration peak.

Performance requirement: During the vibration test, the apparatus shall not suffer any loss of function and shall not give a false alarm or fault signal. The apparatus shall not suffer damage resulting in a hazard or loss of function.

The variation of the indication in zero test gas or reference air, and standard test gas from that determined prior to the test shall not exceed ± 0,2 % (v/v) of oxygen or ± 2,5 % of the measuring range, whichever is the greater.

5.4.13.2.4 Procedure 3

For apparatus containing paramagnetic sensors, the vibration shall be as follows:

- 10 Hz to 30 Hz, 1,0 mm total excursion;
- 31 Hz to 150 Hz, 19,6 m/s² acceleration peak.

Performance requirement: During the vibration test, the apparatus shall not suffer any loss of function or errors that invalidate its use for its intended purpose. The apparatus shall not suffer damage resulting in a hazard or loss of function.

The variation of the indication in zero test gas or reference air, and standard test gas from that determined prior to the test shall not exceed ± 0,2 % (v/v) of oxygen or ± 2,5 % of the measuring range, whichever is the greater.

5.4.14 Drop test

This test is applicable only to portable and transportable apparatus. If components of fixed apparatus can be used like portable or transportable apparatus according to the instruction manual, these components shall be considered to be portable or transportable for this test. If the manufacturer recommends that the apparatus be used in its carrying case, the test shall be carried out with the case.

Measurements shall be taken with either zero test gas or reference air, and with standard test gas.

Portable apparatus shall be released, while operating, from a height of 1 m above a concrete surface and allowed to free fall.

Transportable apparatus with a mass less than 5 kg shall be released, while not operating, from a height of 0,3 m above a concrete surface and allowed to free fall.

Other transportable apparatus shall be released, while not operating, from a height of 0,1 m above a concrete surface and allowed to free fall.

The test required above shall be performed three separate times, the portable apparatus being released each time with a different side (surface) facing down at the time of release and the transportable apparatus to be in an orientation for normal transport.

Repeat the measurements with either zero test gas or reference air, and with the standard test gas.

Performance requirement: The apparatus shall not suffer damage resulting in a hazard or loss of function (e.g. alarm, pump function, controls, display). The variation of the indication in zero test gas or reference air, and standard test gas from the value determined before the drop test shall not exceed ± 0,2 % (v/v) of oxygen or ± 2,5 % of the measuring range, whichever is the greater.

5.4.15 Warm-up time (not applicable to spot-reading apparatus)

The alarm set point shall be set

a) for apparatus intended for measuring oxygen deficiency: at 10 % relative below the concentration of the reference air,

b) for apparatus intended for measuring oxygen enrichment: at 10 % relative above the concentration of the reference air, and

c) for apparatus intended for measuring inertization: at 10 % of the measuring range.

If the alarm set point cannot be set at this concentration, the alarm shall be set as near as possible to that concentration.

The apparatus shall be switched off and left for 24 h in reference air. After the 24 h period, the apparatus shall be switched on in zero test gas (c) (after 5 min exposure) or reference air (a and b) and the warm-up time measured.

Performance requirements: The apparatus shall warm-up in zero test gas or reference air to give a final indication to within a volume fraction of ± 0,2 % (v/v) of oxygen or ± 2,5 % of the measuring range, whichever is the greater, in a time not exceeding 2 min for portable apparatus or for fixed or transportable apparatus, as specified by the manufacturer, and no false alarms shall be generated.

5.4.16 Time of response (not applicable to spot-reading apparatus)

The apparatus shall be in the as supplied condition and without optional accessories, e.g. collecting cones, weather protection, attached to the sensor for special purposes.

The apparatus or the sensor shall

a) be subjected to a step change from either zero test gas or reference air, to standard test gas,

b) following stabilisation at the standard test gas, be subjected to a step change back to either zero test gas or reference air.

These tests shall be carried out by means of suitable equipment, e.g. a mask or a chamber filled with test gas, into which the sensor is quickly introduced.

Performance requirement: A value of 20 % of the total measured value change shall be reached within 10 s (t_{20}), and a value of 90 % of the total measured value change shall be reached within 45 s (t_{90}).

For apparatus equipped with a sample line or a probe, 3 s per metre length of sample line or probe shall be added to these values.

5.4.17 Minimum time to operate (spot-reading apparatus)

The standard test gas shall be applied to the apparatus simultaneously with the initiation of the measurement procedure.

Performance requirement: For apparatus without a probe or sample line, the indication shall reach 90 % of the final value in a time not exceeding 15 s.

For apparatus equipped with a sample line or a probe, 3 s per metre length of sample line or probe shall be added to these values.

5.4.18 Battery capacity

5.4.18.1 Battery-powered continuous duty apparatus

With a battery fully charged at the beginning of the test, an initial measurement in either zero test gas or reference air and in standard test gas shall be taken. Then the apparatus shall be operated either in zero test gas or reference air for a total period of

a) 8 h, if fitted with a user-operable on/off switch, or

b) 10 h, if not so fitted.

The measurement shall be repeated at the end of the specified period, and also 10 min after indication that the low-battery condition has been reached.

Performance requirement: The variation of the indication in zero test gas or reference air, and in standard test at the end of the specified period shall not exceed ± 0,2 % (v/v) of oxygen or ± 2,5 % of the measuring range, whichever is the greater.

At the end of the further 10 min following the indication of the low-battery condition, the variation of the indication in zero test gas or reference air, and in standard test shall not exceed ± 0,4 % (v/v) of oxygen or ± 5 % of the measuring range, whichever is the greater.

5.4.18.2 Battery-powered spot-reading apparatus

With a battery fully charged at the beginning of the test, an initial measurement in either zero test gas or reference air and in standard test gas shall be taken. Then the apparatus shall be operated in either zero test gas or reference air 200 times.

The duration of each operation shall be equal to the minimum time of operation. One min shall elapse after each operation.

The initial measurement shall be repeated at the end of the 200 operations.

The cycle of operations shall then be continued until an indication that the low-battery condition has been reached. The apparatus shall be operated for an additional 10 times. The initial measurement shall be repeated afterwards.

Performance requirement: The variation of the indication in zero test gas or reference air and in the standard test at the end of the 200 operations shall not exceed ± 0,2 % (v/v) of oxygen or ± 2,5 % of the measuring range, whichever is the greater.

At the end of the further 10 operations following the indication of the low-battery condition, the variation of the indication in zero test gas or reference air, and in the standard test gas shall not exceed ± 0,4 % (v/v) of oxygen or ± 5 % of the measuring range, whichever is the greater.

5.4.19 Power supply variations

The apparatus shall be set up at nominal supply voltage and, where appropriate, rated frequency. For apparatus with remote sensors, the test shall be performed with both maximum and minimum resistance of the interconnecting cable.

The alarm set point shall be set

a) for apparatus intended for measuring oxygen deficiency: at 10 % relative below the concentration of the reference air,

b) for apparatus intended for measuring oxygen enrichment: at 10 % relative above the concentration of the reference air, and

c) for apparatus intended for measuring inertization: at 10 % of the measuring range.

If the alarm set point cannot be set at this concentration, the alarm shall be set as near as possible to that concentration.

The apparatus shall be tested at both 115 % and 80 % of nominal supply voltage. Where the manufacturer of the apparatus specifies another supply range, the apparatus shall be tested at the upper and lower limits of the supply voltage specified by the manufacturer.

It shall be verified at the minimum supply voltage that all output functions are working properly even at the maximum load conditions.

NOTE 1 This includes testing of analogue outputs at the maximum load and maximum current.

NOTE 2 This includes testing that relays are able to energize at the minimum supply voltage.

Performance requirement: The variation of the indication at the highest and lowest supply voltage in zero test gas or reference air, and standard test gas shall not exceed ± 0,2 % (v/v) of oxygen or ± 2,5 % of the measuring range, whichever is the greater. No false alarm shall be activated. All output functions shall work properly.

5.4.20 Electromagnetic compatibility

The apparatus shall be set under normal conditions, in accordance with 5.3, and then shall be subjected to the tests specified in EN 50270.

Performance requirement: The apparatus shall fulfil the requirements specified in EN 50270.

NOTE If legal requirements for electromagnetic compatibility allow the manufacturer to declare the conformity by applying EN 50270 or other relevant standards, this test may be omitted.

5.4.21 Addition of sampling probe

When it is intended to add a sampling probe, the apparatus shall first be tested using either zero test gas or reference air, and the standard test gas without the sampling probe. The sample probe shall then be added, and the test repeated.

Performance requirement: The variation of the indication in either zero test gas or reference air, and standard test gas shall not exceed ± 0,2 % (v/v) of oxygen or ± 2,5 % of the measuring range, whichever is the greater.

5.4.22 Dust (for apparatus where the atmosphere is sampled by diffusion only)

The initial measurement shall be recorded using standard test gas. The effect of dust shall then be simulated by reducing the gas inlet area of the apparatus by 50 % before subjecting it to standard test gas.

Performance requirement: The variation of the indication in standard test gas shall not exceed ± 0,2 % (v/v) of oxygen or ± 2,5 % of the measuring range, whichever is the greater. The increase in t_{90} shall be less than 10 s.

5.4.23 Poisons and other gases

5.4.23.1 General

The following tests shall not be carried out when the use of the apparatus in these gas mixtures is expressly prohibited in the instruction manual.

The gas mixtures may be prepared by means of any suitable method. The deviation from the nominal volume fractions of all components shall be within 10 % relative.

5.4.23.2 Apparatus with electrochemical sensors

An initial measurement shall be taken either in zero test gas or reference air, and in standard test gas.

Then the apparatus shall be tested for 1 week in a mixture of 5 % (v/v) carbon dioxide in reference air (apparatus intended for measuring oxygen deficiency or enrichment) or in standard test gas (apparatus intended for measuring inertization).

A final measurement shall be taken either in zero test gas or reference air, and in standard test gas.

Performance requirement: At the beginning and at the end of the application of the carbon dioxide test gas, the deviation of the indication from the initial indication in pure reference air or pure standard test gas shall not exceed ± 0,4 % (v/v) of oxygen or ± 5 % of the measuring range, whichever is the greater. The change of oxygen volume fraction shall be compensated when determining the deviation.

5.4.23.3 Apparatus with zirconium dioxide (ZrO_2) sensors

Unless otherwise specified, an initial measurement in standard test gas shall be recorded, then the apparatus shall be tested for 5 min in a mixture of 50 % (v/v) methane and 50 % (v/v) nitrogen, and a final measurement in standard test gas shall be recorded.

Performance requirement: The variation of the initial and final indication in pure standard test gas shall not exceed ± 0,4 % (v/v) of oxygen or ± 5 % of the measuring range, whichever is the greater.

5.4.24 Field verification kit

If a field verification kit (e.g. a calibration mask) is provided with the apparatus, first the apparatus shall be calibrated without the field verification kit using the standard test gas. Then the field verification kit shall be used in a manner corresponding to the manufacturer's instructions for checking the apparatus response. The final measurement in standard test gas shall be recorded.

Performance requirement: The deviation of the indication observed during the use of the field verification kit shall not exceed ± 0,1 % (v/v) of oxygen or ± 1 % of the measuring range, whichever is the greater.

5.4.25 Operation at or below the lower limit of the measuring range

An initial measurement shall be taken either in zero test gas or reference air, and in standard test gas.

The apparatus shall then be operated continuously in pure nitrogen for a period of 1 h followed by the application of standard test gas for 5 min.

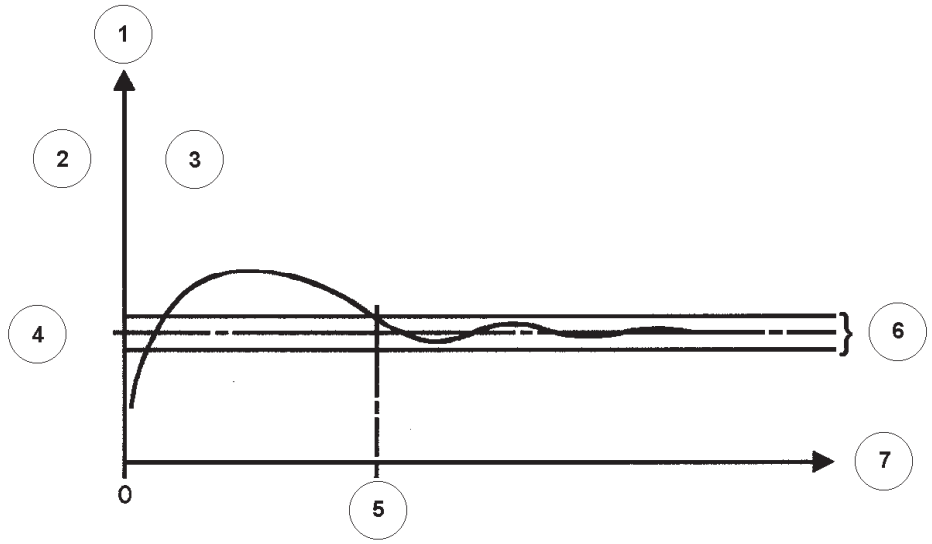
A final measurement shall be taken either in zero test gas or reference air, and in standard test gas.

Performance requirement: During the application of nitrogen, active alarms shall remain in operation. The under-range condition shall be signalled for apparatus with a lower limit of the measuring range above zero. After the removal of nitrogen, the apparatus shall return to normal operation within 5 min. The variation of the indication in zero test gas or reference air, and standard test gas from that determined prior to the test shall not exceed ± 0,2 % (v/v) of oxygen or ± 2,5 % of the measuring range, whichever is the greater.

5.4.26 Verification of software and digital components

Design and function of the apparatus using software and/or digital technologies shall be evaluated and tested according to 4.2.9.

Performance requirement: The apparatus shall fulfil the requirements of EN 50271.



Key

1 Indication

2 Power off in reference air or in zero test gas

3 Power on in reference air or in zero test gas

4 Indication of 20,9 % (v/v) of oxygen or indication of standard test gas

5 Warm-up time

6 Specified tolerance band of indication in reference air or zero test gas

7 Time

Figure 1 − Warm-up time in reference air or in zero test gas (typical)

Annex A
(informative)

Sequence of tests

It is recommended that the tests are carried out in the following sequence:

1	Verification of software and digital components	[5.4.26]
2	Unpowered storage	[5.4.2]
3	Preparation of apparatus before testing	[5.2.2]
4	Calibration, adjustment and repeatability	[5.4.3]
	Operation below the measuring range	[5.4.25]
	Alarm set point(s)	[5.4.6]
	Flow rate	[5.4.11]
	Orientation	[5.4.12]
	Warm-up time (not applicable to spot-reading apparatus)	[5.4.15]
	Time of response	[5.4.16]
	Minimum time to operate (spot-reading apparatus)	[5.4.17]
	Addition of sampling probe	[5.4.21]
	Field verification kit	[5.4.24]
	Battery capacity	[5.4.18]
	Power supply variations	[5.4.19]
	Electromagnetic compatibility	[5.4.20]
	Dust (for apparatus where the atmosphere is sampled by diffusion only)	[5.4.22]
5	Vibration	[5.4.13]
	Drop test	[5.4.14]
6	Temperature	[5.4.7]
	Pressure	[5.4.8]
	Humidity	[5.4.9]
	Air velocity	[5.4.10]
7	Stability (continuous duty apparatus only)	[5.4.4]
	Stability (spot-reading apparatus only)	[5.4.5]
8	Poisons and other gases	[5.4.23]

Annex ZY
(informative)

Significant changes between this European Standard and EN 50104:2002

This European Standard supersedes EN 50104:2002 + A1:2004.

The significant changes with respect to EN 50104:2002 + A1:2004 are as listed below.

	Type		
	Minor and editorial changes	**Extension**	**Substantial change regarding ESR´s [a]**
Modification of the scope of the standard: Alignment to EN 60079-29-1, new measuring principle (TDLAS)	X		
Normative references	X		
Definitions modified for alignment with EN 60079-29-1	X		
General requirements 4.1 to 4.2.2, 4.2.4 to 4.2.6 modified for alignment with EN 60079-29-1	X		
General requirements 4.2.3, 4.2.7 and 4.2.8 modified or new for alignment with EN 60079-29-1		X	X
Clauses 6.1 and 6.2 moved to 4.3 and 4.4, respectively	X		
Requirements to the instruction manual (clause 4.4) extended		X	X
General requirements and normal conditions for tests modified and extended (clauses 5.1, 5.2.1.3, 5.2.1.4, 5.3.2, 5.3.7, 5.3.10, 5.3.11)		X	X
Test method 5.4.2 modified	X		
Test method 5.4.4.1 modified		X	X
Test method 5.4.4.2 modified	X		
Test method 5.4.7 modified		X	X
Requirements for test 5.4.8 modified	X		
Test method 5.4.13 modified for alignment with EN 60079-29-1	X		
Test method 5.4.14 modified		X	X
Requirements for test 5.4.15 modified	X		
Test method 5.4.19 modified		X	X
Requirements for test 5.4.22 modified		X	X
Requirements for test 5.4.23.2 modified	X		
Requirements for test 5.4.24 modified		X	X
New tests 5.4.25 and 5.4.26		X	X
[a] ESR = Essential Health and Safety Requirements (Annex II of Directive 94/9/EC).			

General conclusion on the change of the State of the Art by this standard

CLC/SC 31-9 as the responsible committee has concluded that this new edition contains substantial changes regarding the ESRs.

Annex ZZ
(informative)

Coverage of Essential Requirements of EC Directives

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and within its scope the standard covers only the following essential requirements out of those given in Annex II, Subclauses 1.5.5 to 1.5.8 of the EC Directive 94/9/EC:

– ER 1.5.5 to 1.5.7 – the essential safety requirements for devices with a measuring function for explosion protection

– ER 1.5.8 – the risks arising from software

Compliance with this standard provides one means of conformity with the specified essential requirements of the Directive(s) concerned.

WARNING: Other requirements and other EC Directives may be applicable to the products falling within the scope of this standard.

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